Space Weather Technical Forecast

Issued on Monday, 11 March 2024 at 13:11 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of G1/Minor Storms, especially 11 March due to CME arrivals or high speed stream connections. Chance of M-class flares throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with one M7.4 flare emanating from AR3599 at 10/1213UTC, followed by a C6.9 flare which appeared to be from a combination of AR3599 and AR3600. There are five sunspot regions on the visible disc, with AR3599 the largest and most complex region on the visible disc, with a persistent delta region. The remaining regions are all simple and benign. A partial halo CME emanating from AR3599 following the M7.4 flare on the 10 March is currently undergoing analysis for any potential Earth-directed component - pending analysis.

Solar Wind / Geomagnetic Activity: Solar wind speeds as observed at L1 by ACE, started the period at Slightly Elevated levels, near 450km/s, with steady declining trend to the current slow-ambient levels, near 380km/s. Density started the period below average, with a steady rise to average by end of the period. Total magnetic field strength has been weak, below 6nT, with the north-south component, Bz, varying between +3nT and -4nT. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity has been Quiet (Kp 0-2) throughout.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux became slightly elevated following the M7.4 flare, before returning to mostly background levels. High energy electron flux (greater than 2MeV) observed at GOES16 has been at background levels with a peak at 739pfu at 10/1935UTC. The associated 24 hour fluence was well below the Active (1e8 integrated pfu) threshold. The observed 24-hour fluence at 11/0000 UTC was 2.38e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a chance of M-class flares mainly from AR3599 which will remain on the visible disc through much of the forecast period.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 07 March may arrive at Earth on Day 1 (11 March), but with low confidence. A further potential partial halo CME, which is currently undergoing analysis, could affect Earth by the end of the period. The current high speed stream is expected to continue to wane, with a further weak high speed stream from coronal hole 07 possibly connecting on Day 1 (11 March). CH09/+ near centre disc is unlikely to cause any significant enhancement due to its positive polarity and also approaching the spring equinox.

Geomagnetic activity is expected to be Quiet to Unsettled. There is a chance of Active and slight chance of G1/Minor Storm intervals from either the CME arrivals or the possible onset of the coronal hole high speed stream on 11 March. There is lower confidence of Active or G1/Minor

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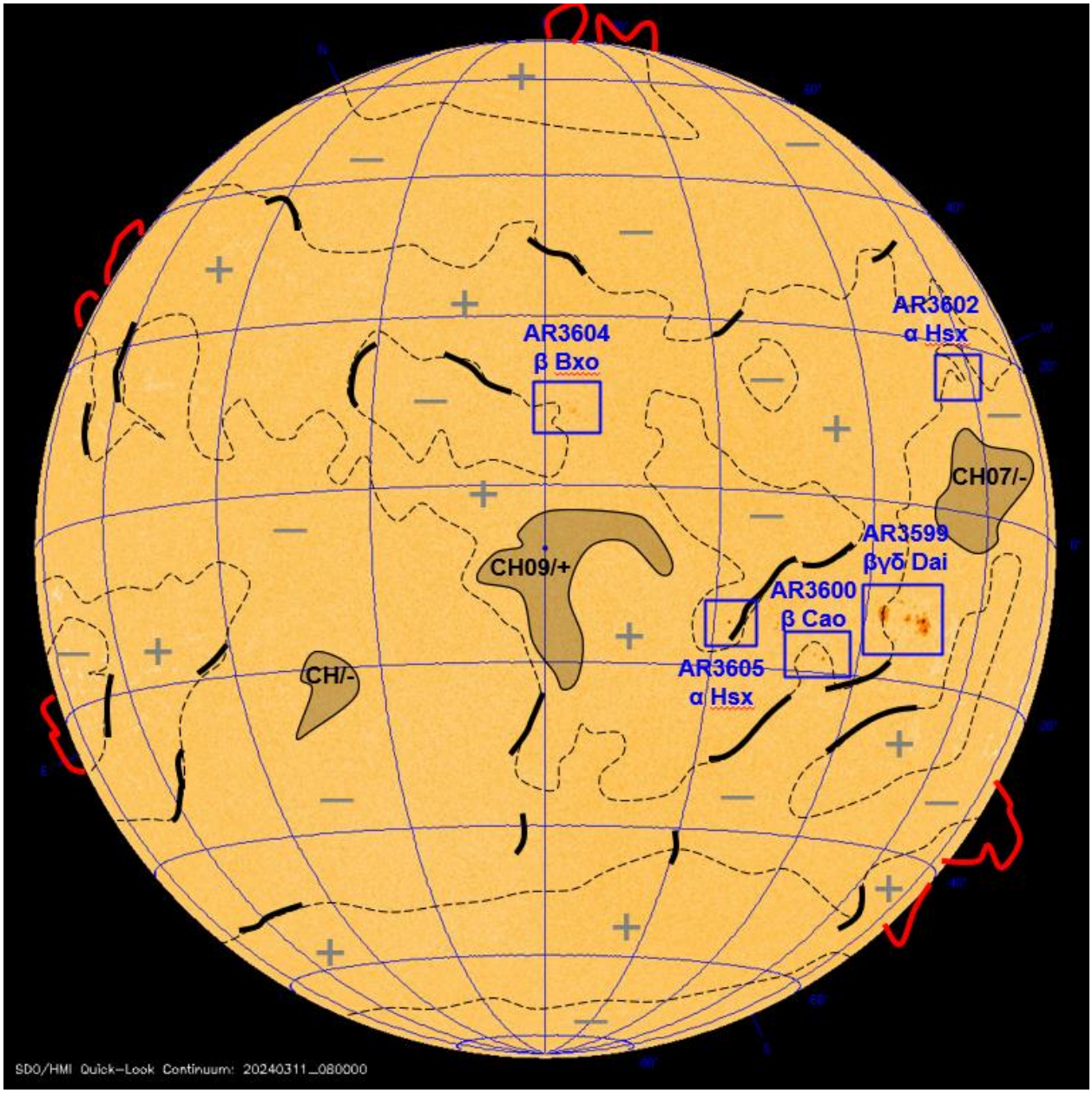
Storm intervals towards the end of the period due to the as yet unanalysed partial halo CME from 10 March - pending results.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is expected to persist at background or close to background levels, with a very slight chance of S1 radiation storms, with the main risk from AR3599. GOES16 high energy electron flux is expected to remain at mainly moderate levels, with an increasing risk of exceeding the high threshold on diurnal peaks, subject to complicating effects from CME arrivals. Electron fluence is forecast to be below the Active threshold but with a rising trend.

Figure 1. Solar Analysis Valid 11/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 07 March may glance the Earth on 11 March, but with low confidence. A further potential partial halo erupted from AR3599 following an M7.4 flare at 10/1213UTC. Despite some coronal dimming being visible on multiple wavelengths, coronagraph imagery is currently inconclusive, with further analysis needed of this event once further imagery is available.

The Earth is otherwise under the influence of a weakening high speed stream from coronal hole 06. Coronal hole 07 is also due to connect with the Earth on 11 March, but any connection could be masked by the current coronal hole or by the CME arrival. Coronal hole 09 near center-disc is not expected to bring any significant enhancement in geomagnetic activity due to its positive polarity, especially as we approach the spring equinox.

Geomagnetic activity is forecast to be Quiet to Unsettled, but with a risk of Active or G1/Minor Storms on 11 March due to high speed stream onset or CME arrival. Confidence is low towards the end of the period with a potentially Earth-directed partial halo CME, although this is currently undergoing further analysis.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
07/2215 UTC	Partial	Filament	NW	450km/s	11/0600 UTC	Low confidence. Glancing shock possible

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Figure 2: A very faint partial halo CME seen in LASCO-C2 (left), which is observed better in the 'difference imagery' in the CAT tool (right). This feature is currently being analysed for any potential Earth-directed component.

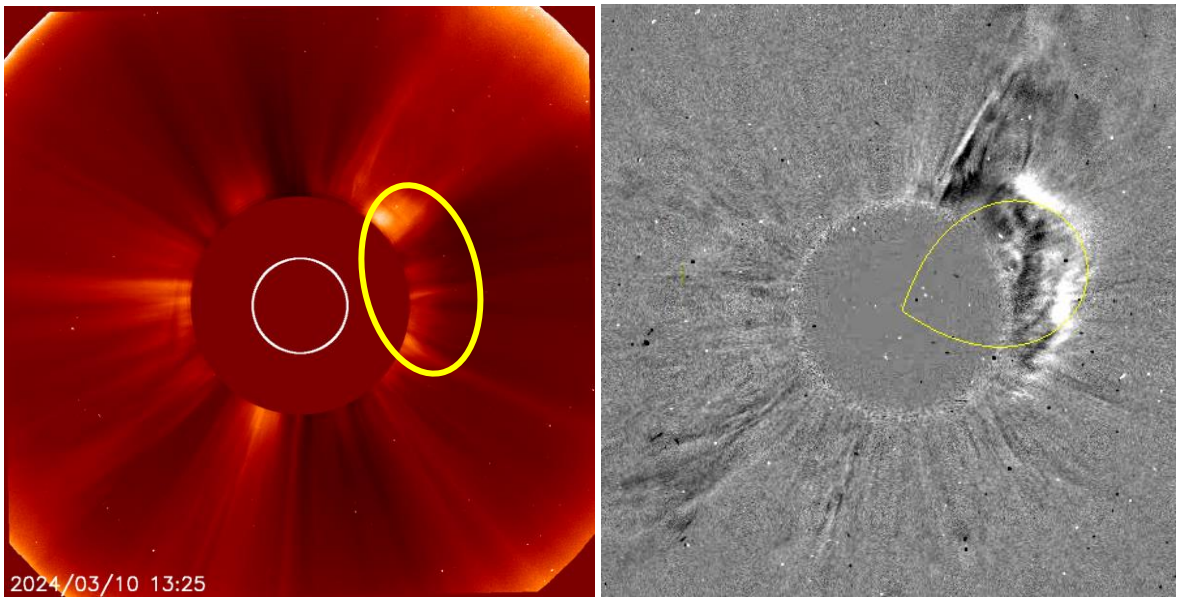
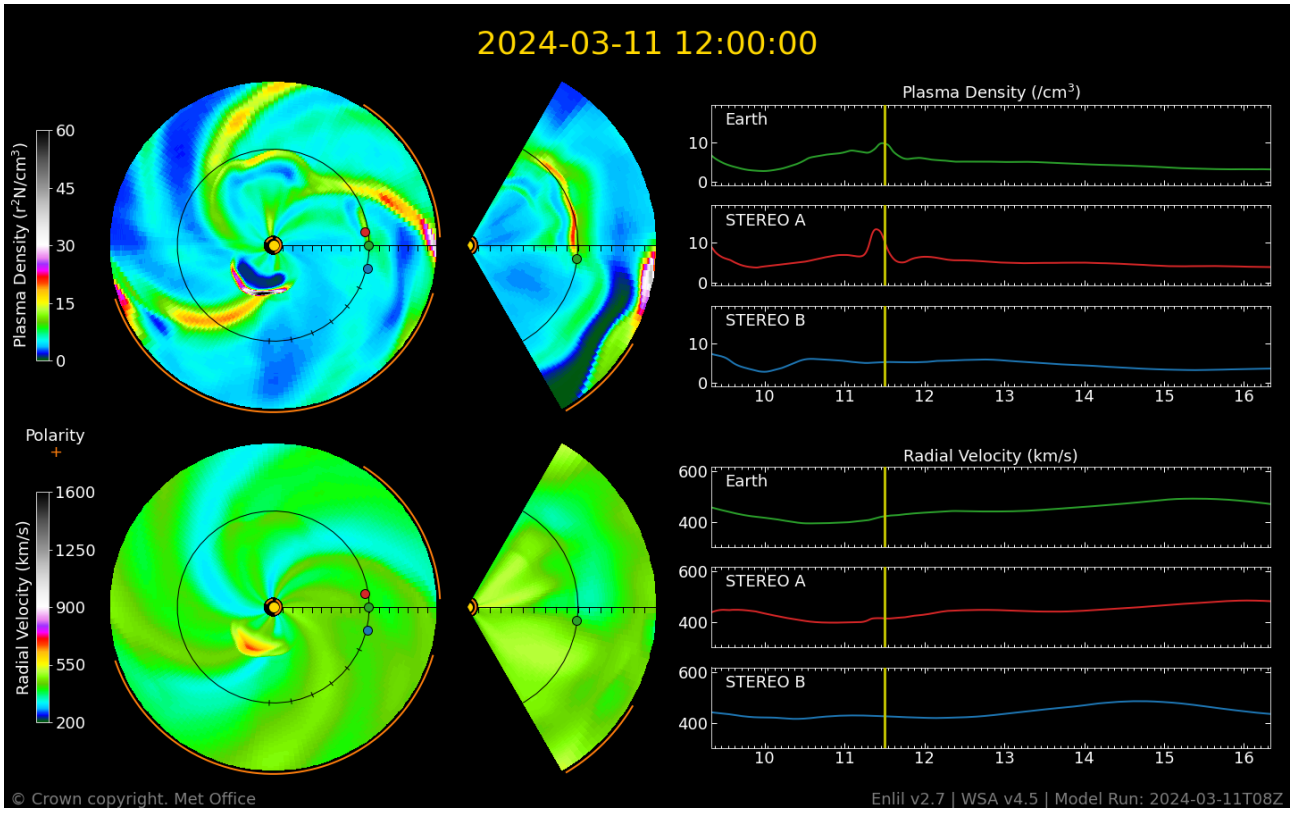


Figure 3: MOSWOC ENLIL (top) and Ensemble (bottom) – shows potential glancing blow from 07 March CME due today (11 March).



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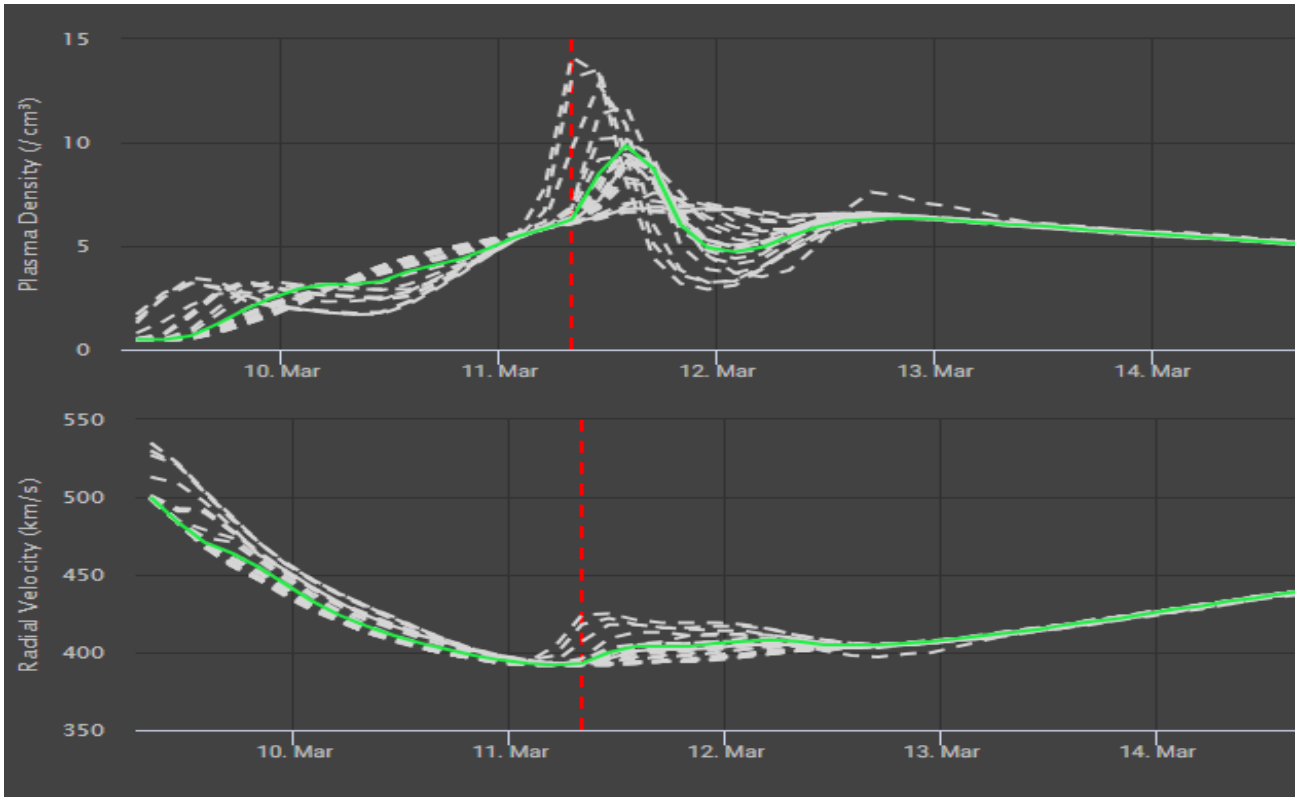

Radio Blackouts - X-Ray Flares:

AR3599 is the largest and most complex region on the visible disc, with a βγδ configuration. The region has become increasingly active though the last 24 hours, with a M7.4 flare and a potential partial halo CME, which is currently being analysed. This was followed by a further C6.9 flare which led to a radio burst and appears to be due to a combination of flaring from AR3599 and AR3600. Despite continual small evolutions in AR3599, the central delta spot in the leader portion has matured. The remaining regions are all weak and generally inactive.

Solar activity is expected to be mainly Low, with a chance of Moderate activity, particularly from AR3599.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	30	30	30
Very Active	R3 to R5 X Class	No	10	10	10	10

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Figure 4: GOES X-Ray flare trace.

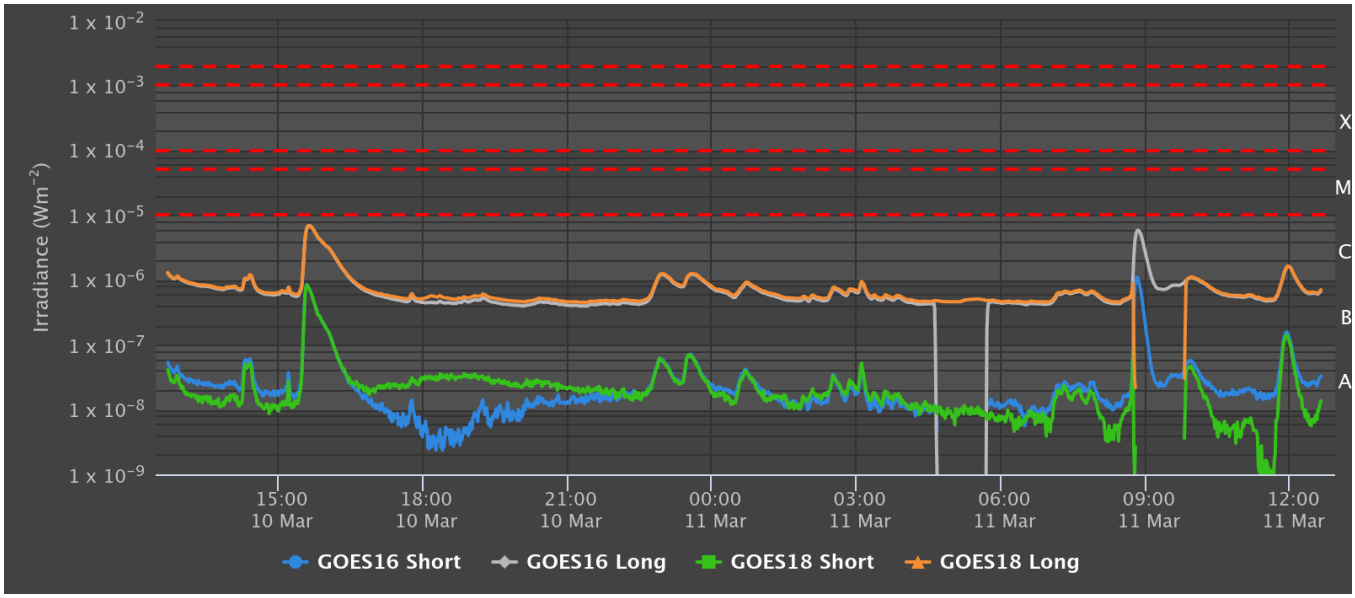
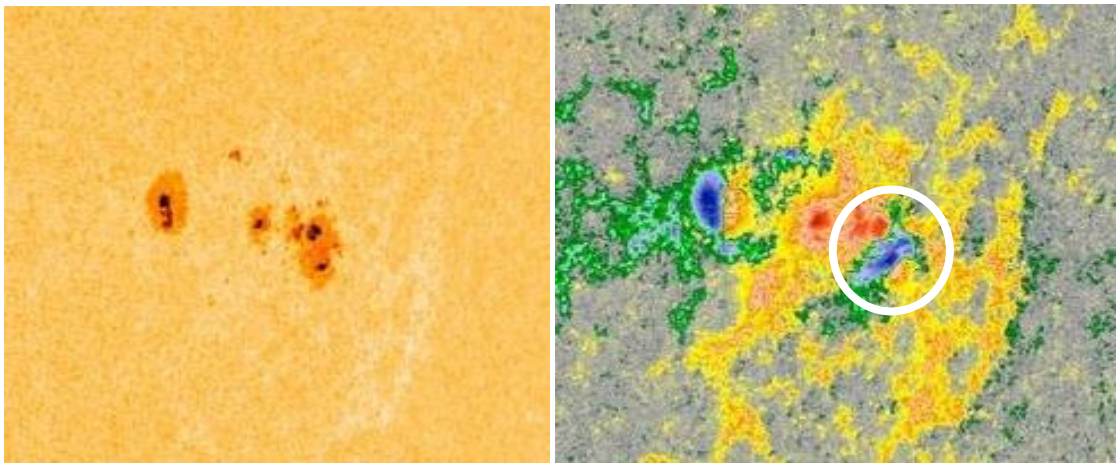


Figure 5: AR3599 in both SDO HMI intensitygram and magnetogram imagery with the delta spot seen in its leading portion.



Solar Radiation Storms - (High Energy Protons):

GOES18 proton flux is currently close to background. Recent flaring from AR3599 appears to have led to a slight increase above background, suggesting a potential for radiation storms from any significant flare activity.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	10	10	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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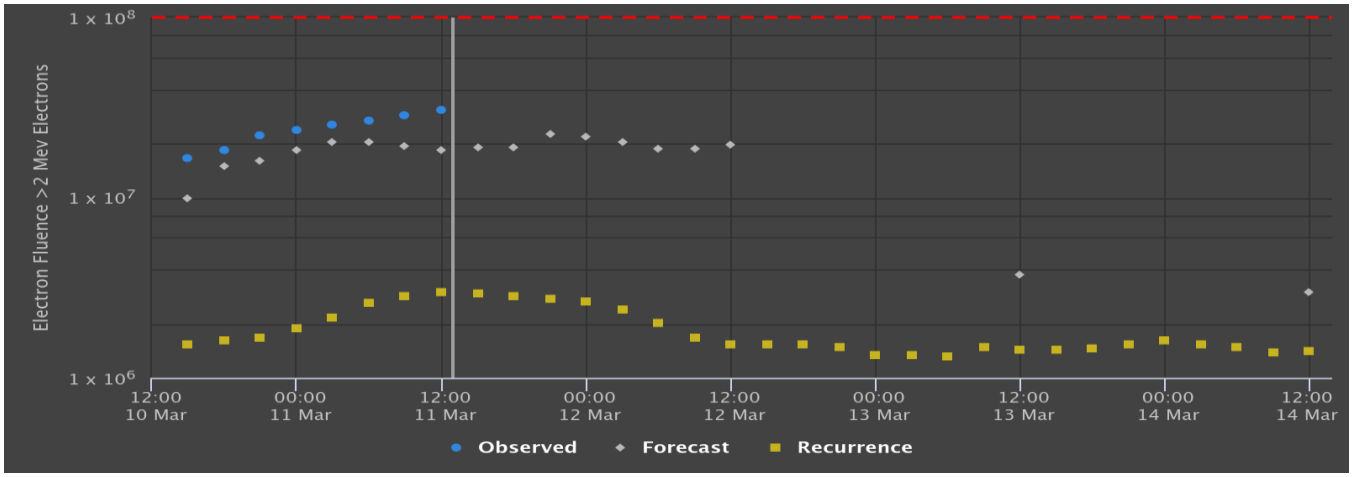
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) has been at mainly moderate levels in the presence of a slightly elevated but declining high speed stream. A further high speed stream may connect on 11 March, but this is a weak feature, so the magnitude of any high speed stream is uncertain. A potential CME arrival on 11 March and uncertainty around CMEs later in the period complicate the evolution of the forecast, but the continued anticipated input of electrons into the radiation belts is likely to lead to an eventual increased risk of reaching the high threshold.

Electron fluence is expected to increase through the period on a fitful trend based on potential impacts to the electron flux. There is a likelihood that the Active threshold will be approached but not exceeded during the period.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	10	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: MOSWOC REFM – electron fluence, observations and recurrence.



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